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AP Research Performance Task Rubric: Academic Paper

Content Area	Performance Levels		
1 Understand and Analyze Context	The paper identifies the topic of inquiry. 2	The paper identifies the topic, and describes the purpose and focus of the inquiry. 4	The paper explains the topic, purpose, and focus of the inquiry and why further investigation of the topic is needed by connecting it to the larger discipline, field, and/or scholarly community. 6
2 Understand and Analyze Argument	The paper identifies or cites previous works and/or summarizes a single perspective on the student's topic of inquiry. 2	The paper summarizes, individually, previous works representing multiple perspectives about the student's topic of inquiry. 4	The paper explains the relationships among multiple works representing multiple perspectives, describing the connection to the student's topic of inquiry. 6
3 Evaluate Sources and Evidence	The paper uses sources/evidence that are unsubstantiated as relevant and/or credible for the purpose of the inquiry. 2	The paper uses credible and relevant sources/evidence suited to the purpose of the inquiry. 4	The paper explains the relevance and significance of the used sources/cited evidence by connecting them to the student's topic of inquiry. 6
4 Research Design	The paper presents a summary of the approach, method, or process, but the summary is oversimplified. 3	The paper describes in detail the approach, method, or process. 5	The paper provides a logical rationale by explaining the alignment between the chosen approach, method, or process and the research question/project goal. 7
5 Establish Argument	The paper presents an argument, conclusion or understanding, but it is simplistic or inconsistent, and/or it provides unsupported or illogical links between the evidence and the claim(s). 3	The paper presents an argument, conclusion, or new understanding that the paper justifies by explaining the links between evidence with claims. 5	The paper presents an argument, conclusion or new understanding that acknowledges and explains the consequences and implications in context. 7
6 Select and Use Evidence	Evidence is presented, but it is insufficient or sometimes inconsistent in supporting the paper's conclusion or understanding. 2	The paper supports its conclusion through the compilation of relevant and sufficient evidence. 4	The paper demonstrates a compelling argument through effective interpretation and synthesis of the evidence and through describing its relevance and significance. 6
7 Engage Audience	Organizational and design elements are present, but sometimes distract from communication or are superfluous. 1	Organizational and design elements convey the paper's message. 2	Organizational and design elements engage the audience, effectively emphasize the paper's message and demonstrate the credibility of the writer. 3
8 Apply Conventions	The paper cites and attributes the work of others, but does so inconsistently and/or incorrectly. 2	The paper consistently and accurately cites and attributes the work of others. 4	The paper effectively integrates the knowledge and ideas of others and consistently distinguishes between the student's voice and that of others. 6

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9 Apply Conventions	The paper's use of grammar, style and mechanics convey the student's ideas; however, errors interfere with communication and/or credibility. 1	The paper's word choice and syntax adheres to established conventions of grammar, usage and mechanics. There may be some errors, but they do not interfere with the author's meaning. 2	The paper's word choice and syntax enhances communication through variety, emphasis, and precision. 3

NOTE: To receive the highest performance level presumes that the student also achieved the preceding performance levels in that row.

ADDITIONAL SCORES: In addition to the scores represented on the rubric, readers can also assign scores of **0** (zero).

- A score of **0** is assigned to a single row of the rubric when the paper displays a below-minimum level of quality as identified in that row of the rubric.

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AP® RESEARCH
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Academic Paper

Overview

This performance task was intended to assess students' ability to conduct scholarly and responsible research and articulate an evidence-based argument that clearly communicates the conclusion, solution, or answer to their stated research question. More specifically, this performance task was intended to assess students' ability to:

- Generate a focused research question that is situated within or connected to a larger scholarly context or community;
- Explore relationships between and among multiple works representing multiple perspectives within the scholarly literature related to the topic of inquiry;
- Articulate what approach, method, or process they have chosen to use to address their research question, why they have chosen that approach, and how they employed it;
- Develop and present their own argument, conclusion, or new understanding;
- Support their conclusion through the compilation, use, and synthesis of relevant and significant evidence;
- Use organizational and design elements to effectively convey the paper's message;
- Consistently and accurately cite, attribute, and integrate the knowledge and work of others, while distinguishing between the student's voice and that of others;
- Generate a paper in which word choice and syntax enhance communication by adhering to established conventions of grammar, usage, and mechanics.

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The Neuroscience of Creativity as Shown Through the Neural Abnormalities of Bipolar Disorder and Schizophrenia

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Abstract

The following research paper attempts to explore the topic of creativity and its potential root in neuroscience. This research is intended to find possible connections between the neural abnormalities in bipolar and schizophrenic patients and subjects exhibiting high creativity in order to connect a stronger scientific basis for the neuroscience of creativity. The research method utilized was all of a secondary nature, including **c**orrelational research and extensive content analysis based off the past findings of various academic journals. Analysis hints at a possible connection in structural abnormalities, particular with bipolar disorder subjects, but finds no connection with white and gray matter.

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The Neuroscience of Creativity as Shown Through the Neural Abnormalities of Bipolar Disorder and Schizophrenia

Creativity is the driving force behind the greatest paintings, novels, and compositions of our time. It inspires innovation and the solving of the seemingly senseless. However, while creativity envelops some, it evades others. The root of creativity is still being searched for, with several theories existing as to what the source is. Some state that creativity is relative, and that if one takes the proper perspective, anybody can be creative. However, the operational definition of creativity in most longitudinal/case studies is a person who has won a major prize in one's creative field (artistic or scientific professions) or somebody who specializes in divergent thinking (the ability to come up with many responses to carefully selected questions or probes). (Andreasen 2015). The theories regarding this topic revolve around creativity being rooted in the neuroscience of the brain. This includes the idea of creative individuals suffering from mental illness, as well as having specific brain regions that exhibit creativity in a more obvious way than the average human. The latter discusses brain structures that may be more advanced as well as the actual matter of the brain differing from those who are not considered creative. In this paper, the source of creativity will be investigated. It is hypothesized that creativity can exhibit itself through conditions such as bipolar disorder, through the association cortices of the brain, and through the density of the gray matter of the brain. The following literature reviews attempt to demonstrate and support this hypothesis.

Literature Review

Correlation Between Mental Illness and Creativity:

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In a study completed by Kari Stefansson (found and CEO of genetics company deCODE) (2015), the biology and gene aspect of creativity was examined through its correlation with mental illness. The study strove to discover whether those who occupied creative professions were more likely to carry the gene variants associated with mental illness. The scientists examined genetic and medical information from 86,000 Icelanders (35,000 deemed creative through profession or through answers to a questionnaire) to discover genetic variants that doubled the average risk of schizophrenia, and raised the risk of bipolar disorder by more than a third. By checking their findings in large medical databases held in the Netherlands and Sweden, the researchers found that the individuals deemed creative were nearly 25% more likely to carry the mental disorder variants (Stefansson 2015). Stefansson believed that the genes in question specifically increase the risk of schizophrenia and bipolar disorder.

An additional study completed by Nancy C. Andreasen (1987) also hypothesized a relationship between creativity and psychosis, specifically schizophrenia. This study was conducted at the University of Iowa, home to the Writers' Workshop, also known as the oldest and most famous creative writing program in the United States. The subjects included 30 creative writers and 30 noncreative comparison subjects. Extensive interviews were conducted with all participants in order to find evidence of a past or current psychological disorder. The original hypothesis of schizophrenia being the most prevalent mental illness was quickly disproved, as a full 80 percent of the creative subjects had some kind of mood disturbance (mostly depression, but occasionally bipolar disorder) in their lives, compared to thirty percent of the noncreative group (Andreasen 1987). When the families of the creative individuals were examined, both mood disorder

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and creativity were overrepresented, meaning they felt a similar affliction, thus promoting the idea of creativity being as genetic as mental disorder.

Creativity and Neural Abnormalities:

Next, the source of creativity in regards to the neuroscience of the brain was covered in an additional brain imaging study, also by Nancy C. Andreasen (1995). This study developed from the idea of the association cortices being the most extensively developed regions in the human brain, helping us to interpret and make use of the specialized information collected by the primary visual, auditory, sensory, and motor regions of the mind (Andreasen 2014). The subjects in this study included 30 highly creative artists, 30 highly creative scientists, and 30 noncreative comparison (control) subjects. Using a PET (positron-emission tomography) scan, Andreasen examined random episodic silent thought, or free association where the subjects are able to let their minds wander. In all individuals it was found that the association cortices were wildly active during this free thought, with the creative individuals experiencing a higher level of activity in the areas of such cortices. This goes to prove Andreasen's concept of peoples' differing verbal lexicons, or associated memories and meanings that can be accessed for reading, speaking, listening, and writing. Writers like Shakespeare will be found to have a larger and richer verbal lexicon in his or her association cortices than the average stockbroker (Andreasen 1995). Additional studies (Andreasen 2005, Dietrich 2004, Fink et al 2007) also indicate an activation of the dorsolateral prefrontal areas, particularly the areas of the occipital (visual), parietal (general processing), and temporal central crack (hearing and memory) during periods of creativity. Going back to the idea

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of mental illness and creativity, these are exactly the neurological structures that are known to be responsible for the poor cognitive functioning in people with psychiatric disorders or mental dysfunction (Cosman, Pirvu, Trifu 2014).

An additional neuroscience study conducted on creativity examined the matter of the brain instead of attempting to tie creativity to a specific neural structure. This study examined the verbal creativity of 71 participants as the participants exhibited divergent thinking. EEG (electroencephalogram) studies on these individuals revealed a consistent pattern of right-lateralized (right hemisphere of the brain) neural activity over posterior parietal and occipital sites. This may define the regions where skills for divergent thinking emerge. The results of this study also revealed that verbal creativity was positively associated with gray matter density in groups concerning the right cuneus and the right precuneus. This brought the researchers to the conclusion that increased gray matter density in such regions may be telling of vivid imaginative abilities in creative individuals (Benedek, Fink, Hutterer, Koschutnig, Steiner, Weber 2014).

Conclusion:

Taken together, the results from these sources show the aspects of neuroscience are a solid indicator of a source of creativity. Those who suffer from certain mood disorders, bipolar disorders, or schizophrenia may exhibit increased creative tendencies compared to somebody of sound mind. Along with this theory, individuals with richer verbal lexicons, more advanced association cortices, and enhanced gray matter density in certain regions of the brain may also exhibit higher levels of creativity. The theories from these literature reviews should continue to be explored, along with their relation to each other. But what should also be examined is how these different theories correlate

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with each other. It is evident that the neuroscience of creative individuals has been explored, the connection of mental illness and creativity has been examined, and neural structures of those suffering from mental illness have been studied. However, by compiling data and details from the above studies and related experiments, one can gain a fuller understanding of how mental illness, creativity, and neuroscience interweave and affect each other (or not).

Methods

Intent and Expected Outcome of Research:

Nature vs. nurture is a common debate within the worlds of psychology and neuroscience. As somebody drawn to the workings of the brain and also somebody involved in the arts, I had a strong interest in how the mind controls (or doesn't control) creativity. My research question was originally just exploring the correlation between mental illness and creativity. Because of my confinement to secondary sources (which will be explained in the following section) and the fact that this has already been researched through surveys and case studies, as shown in the earlier literature review, I switched to an analysis of the neural abnormalities associated with creativity, the mental illnesses associated with creativity, and whether or not there are similarities in these categories. I hope to find a scientific basis that connects these separate studies and utilizes the field of neuroscience to prove them possible. Because mental illness is something wholly based in neuroscience, if there is a link discovered between the neural abnormalities of mental illnesses and creativity, the theory of creativity being rooted in the science of the mind will be supported. My research has examined the structures of

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the brain, their functions, and the definition of creativity. All of this information has been presented by various psychological associations and independent researchers. Arts and creative therapies are already being employed for mental disorder patients, but if an actual link was found in the direct science of the brain and creative ability, then this therapy method could be developed even further.

Methods Employed:

Because of limited time and resources, the methods used to find a solid conclusion in this paper will be wholly secondary. Though original data and information will not be utilized, hopefully a newfound conclusion will shine new light on the neuroscience of creativity. Correlational research and content analysis will be the major methods employed in this paper. Multiple aspects of the topic must be researched and compared in order to find new connections and results.

Reasoning for Methods Employed:

The intention is to prove whether or not the abnormal neural structures found in bipolar disorder and schizophrenia patients correlate with abnormal neural structures found in people exhibiting higher levels of creativity. If similarities are found, then it can demonstrate proof for creativity being rooted in neuroscience rather than environmental causes (supports nature in nature vs. nurture). It will first be discussed as to why schizophrenia and bipolar disorder were the mental illnesses chosen and how they have connected to creativity in the past. This will be shown through longitudinal studies and national health records. The neural abnormalities in these mental disorders will then be identified and described as to their structure and function. Functional imaging and cerebral blood flow studies of creative individuals vs. control individuals will then be

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described and any neural abnormalities will be explained. In later content analysis, these abnormalities will be compared and contrasted. If regional and specific similarities are discovered, then it can be a solid step in displaying the neuroscience of creativity. Because mental illness comes completely from gene and brain aberrations, the scientific aspect of creativity will be emphasized.

Ethical Implications, Acknowledgement of Personal Biases, and Time Constraints:

I did not need to consider the ethical implications of my research or require approval from an Institutional Review Board (IRB) because of the secondary nature of what I was studying. It did not involve any of my own test subjects, interviews, or surveys, since I instead utilized others' hands-on experiments. Because I organized my research into the three categories of mental illness and creativity, neural abnormalities and creativity, and the neural abnormalities of schizophrenia and bipolar disorder, my process was fairly structured. There was a significant amount of information to sift through and deem relevant or not (i.e. scientifically based instead of opinion or symptomatically based). I tend to lean towards the nature side in the nature vs. nurture debate simply because I am educated in psychology and neuroscience and believe that brain is the major control center of our everyday lives. Because of this, I worry that I might have searched for scientific connections that might not necessarily have been there. However, my research was thorough and based off of reliable academic journals, meaning there is little room for personal opinion. The time constraints made it so that I had to focus just on description and neural structures instead of looking at numerically centered neurological studies that would have required extensive codifying and statistical analysis.

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Results

Mental Illnesses Associated with Creativity:

To begin the process of examining a connection between mental illness and the neuroscience of creativity, specific disorders must first be identified. A European longitudinal study points out two possible mental illnesses, schizophrenia and bipolar disorder (Sample 2015). Scientists in Iceland reported that genetic factors that raise the risk of bipolar disorder and schizophrenia are found more often in creative professions (defined as painters, musicians, writers, and dancers). People of such occupations were, on average, 25% more likely to carry the gene variants than professions the scientists judged to be less creative (farmers, manual laborers, and salespeople) (Sample 2015). This is the same study mentioned earlier that was led by Kari Stefansson, found and CEO of deCODE. To reiterate, scientists drew on genetic and medical information from 86,000 Icelanders to find genetic variants that double the average risk of schizophrenia, and raised the risk of bipolar disorder by more than a third (Sample 2015). There was a 17% increase of these variants in members of national arts societies as opposed to non-members. Researchers then checked these findings in large medical databases held in the Netherlands and Sweden. Among these 35,000 people, those thought to be creative were nearly 25% more likely to carry the mental disorder variants (Sample 2015).

Another investigation of the connection between creativity and mental illness emphasizes the symptoms of bipolar disorder (Neihart 1998). Bipolar disorder is a persistent mood disturbance characterized by cyclical, extreme mood swings that include manic states (Neihart 1998). During such mania the individual demonstrates a euphoric

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high or irritable mood. Uncritical self-confidence or grandiosity is often observed. During mania, thoughts race faster than can even be articulated. There is a significant increase in goal-directed activity, meaning individuals may write novels, paint various canvases, or engage in multiple activities simultaneously. Focusing on the thought processes of creative people vs. people suffering from psychosis (a defining characteristic of schizophrenia), there is a similarity regarding translogical thinking (Neihart 1998). This is a type of conceptualizing in which the thinking processes transcend the common ways of ordinary logical thinking (janusian and homospatial processes) (Neihart 1998). These processes mean to combine seemingly unrelated ideas into a single entity.

Neural Abnormalities of Schizophrenia and Bipolar Disorder:

Now that the disorders discovered to be most relevant to creativity have been defined, their neural abnormalities will be examined. Functional magnetic resonance imaging studies work to distinguish between bipolar disorder and schizophrenia (Whalley et. al 2012). In three of four examined studies, over-action of medial temporal lobe structures of limbic/meso-limbic regions in bipolar disorder patients were found. Regions implicated in the disorder included the amygdala, hippocampus, parahippocampal gyrus, and mid-cingulate cortex. Just one study reported over-activation of the mid-cingulate cortex in schizophrenia patients (Whalley et. al 2012). In lateral prefrontal regions, over-action of the dorsal prefrontal cortex in bipolar disorder patients was reported during an emotional prosody (vocal emotion) task. These same results were reported in schizophrenia patients but for an associate memory task for early encoding and early and late memory retrieval instead (Whalley et. al 2012). Over-activation in bipolar disorder patients in the precentral gyrus and lateral parietal cortex

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was also discovered. The regions differentially activated (activated in different places) between the two disorders did not generally overlap with regions differentially activated compared to healthy subjects. Patients with schizophrenia showed abnormal activation during associate memory tasks while patients with bipolar disorder showed increased activation differences during emotional memory tasks (Whalley et. al 2012).

Another study focused in on just bipolar disorder neural abnormalities (Fung et. al 2015). Bipolar disorder patients were found to demonstrate more widespread white matter abnormalities, grey matter volume reductions, and different aberrant functional connectivity in the neural circuitries responsible for emotion regulation, attentional control, and reward processing (Fung et. al 2015). Mania/hypomania symptoms in bipolar disorder have been associated with elevated reward-related activation in dopamine-rich brain regions. When compared to a health control group, patients with bipolar disorder had a thinner caudal anterior cingulate cortex in the right hemisphere, and reduced surface area in the left posterior cingulate cortex. Patients with bipolar disorder also had larger surface area than healthy controls in the left postcentral, precuneus, supramarginal gyri, and in the right superior temporal, insula, and supremarginal gyri (Fung et. al 2015).

Various studies have been performed looking at the symptoms and associated neural abnormalities of schizophrenia specifically. Memory impairment is a consistent schizophrenic symptom. This indicates hippocampal dysfunction, which provokes the decreased memory formation and retention skills of schizophrenia (Wible 2013). The hippocampus is also studied in relation to the amygdala as the amygdala-hippocampal complex (AHC). The Edinburgh High-Risk Study, utilizing structural magnetic

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resonance imaging (sMRI) to calculate the volumes of the AHC, demonstrates significant shrinkage of the complex in patients suffering from schizophrenia (Lawrie 2003). This explains much of the paranoia associated with the disorder. Another abnormality is revealed to be low brain activity in the frontal lobes, which are crucial for planning, reasoning, and problem solving. People diagnosed with schizophrenia have decreased ability in the synchronicity of neural firing in the frontal lobes as well, meaning these out-of-sync neurons can disrupt the integrated functioning of neural networks and therefore contribute to schizophrenia symptoms. Many studies have discovered enlarged, fluid-filled areas and a corresponding shrinkage and thinning of cerebral tissue in schizophrenia patients (Wible 2013). The greater the brain shrinkage, the more severe the disorder and associated symptoms.

Neural Abnormalities of Creativity:

To examine the scientific aspects of creativity, one must look at both any structural abnormalities, as well as any noticeable indications in cerebral blood flow differences as compared to control subjects. First Nancy C. Andreasen's imaging study (1995) will be reiterated. This study utilized the tools of positron emission tomography (PET) and functional magnetic resonance imaging (fMRI) in order to see how the brain "thinks." The experimental task involved studying cognitive ability (verbal fluency, remembering lists of words, recognizing faces, or focusing attention). This task was then compared to when subjects were told to relax (free association where they were allowed to let their minds wander). A PET scan was then used to examine which brain regions were more active during the "resting state" in healthy, normal volunteers. Such technology found activations in multiple regions of association cortices, including frontal,

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temporal, and parietal lobes (front part of the brain, section of the brain near the ears, and section of the brain near the upper-posterior part of the head). Activations were also found in the retrosplenial cingulate (1995). Association cortices are the parts of the brain that make connections between words, allow general processing, bring ideas together, etc. The free association task allowed these cortices to communicate in a free and uncensored manner (1995). Subjects taking part in the task engaged in random free-floating, self-referential thoughts about the past, present, and future (episodic memory) (Andreasen 1995).

Another study examined creativity and intelligence in order to see how such factors can affect academic success (Haier et. al 2008). This described two major schools of thought, separated by the notion of whether creativity is a subset of intelligence or distinct from intelligence. It quickly distinguishes that the two correlate up to a certain threshold (around an IQ of 120). However, it also explains that intelligence and associated knowledge stored within the posterior part of the brain is essential for the creative process to occur (Haier et. al 2008). The study then examined whether the frontal lobes are engaged or whether more posterior brain regions or subcortical structures (example: basal ganglia) are more principal. The functions of such structures were then analyzed at length. As a route to higher cognitive functions such as sustained attention, working memory, and integration of sensory processes, the frontal lobes are necessary regarding the neuroscience of creativity. Regarding the idea of creativity being a result of deliberate and methodical problem solving, frontal brain regions (especially the dorsolateral prefrontal cortex or DLPFC) are required to compel creative product (Haier et. al 2008). The DLPFC specifically is engaged during working memory,

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semantic retrieval, episodic encoding and retrieval, priming, and explicit categorization (Haier et. al 2008).

Associated EEG experiments suggest that a distributed network associated with lower levels of cortical arousal, diminished prefrontal activity, and even frontal inactivity during sleep can be tied to spontaneous creative output (Haier et. al 2008). Earlier EEG studies suggested that highly creative individuals differed from normal controls in greater activity within right parieto-temporal areas, higher alpha activity during analogs of "inspiration," and a greater tendency to present physiological overresponse (Haier et. al 2008). A second EEG group showed greater dimensional complexity over central and parietal cortices when undertaking tasks of divergent thinking (ultimate test of creativity where one has to think "out of the box"). This group had loosened attentional control during creative thinking. A recent group studied 31 normal controls, discovering lower levels of cortical arousal during creative problem-solving and stronger alpha synchronization (brain wave synchronization) in centroparietal cortices associated with more original responses (Haier et. al 2008). Such studies indicate the importance of posterior brain regions, as well as more dispersed frontal activation during performance of creative tasks (Haier et. al 2008).

One must then examine the cerebral blood flow and brain matter studies done regarding creative individuals. A study focusing on the relationship between gray matter morphology and divergent thinking showed whole-brain analysis, specifically examining CAT performance (also known as originality and fluency) (Cousijn et. al 2014). This performance was positively associated with cortical thickness of left-brain areas including the superior frontal gyrus and dispersed occipital, parietal, and temporal areas.

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Radiology analysis indicated that higher CAT originality and fluency were associated with larger cortical thickness of the right MTG (mid temporal gyrus) (Cousijn et. al 2014). Such results suggest a positive relationship between cortical thickness and divergent thinking in the visuo-spatial domain of creativity.

Another study focuses on cerebral blood flow (CBF) during mental rest periods associated with general intelligence and creativity (Takeuchi et. al 2011). Myelin in the axon sheath of neurons allows easier transportation of electron impulses through the axons. The faster the transportation, the quicker the neural impulses and connections. Increased mean white matter rest-CBF is necessary for maintaining the myelinated white matter structures in creative subjects. Increased origodndrgolia (responsible for the metabolic maintenance of the increased myelin sheath) can require increased rest-CBF to keep up their functions (Takeuchi et. al 2011). This shows another way in which increased mean white matter rest-CBF may be associated with creativity. A positive correlation between mean white matter rest-CBF was observed for creativity. Previous diffusion tensor imaging study reported that increased widespread white matter structural integrity (secondary cause to increased myelination) is associated with higher creativity as well (Takeuchi et. al 2011).

Now that the scientific data of creativity and associated mental illnesses has been identified, the neural abnormalities must be analyzed and compared.

Analysis

The white matter and gray matter of creative subjects vs. subjects suffering from bipolar disorder/schizophrenia will first be examined. Gray matter contains the majority

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of the brain's cell bodies while white matter is comprised of the myelin that enables swift neuronal transmission. The studies I examined explained how schizophrenia patients suffered from structural shrinkage (shrinkage of gray matter) (Wible 2013). Bipolar disorder patients were found to have gray matter volume reductions as well. A common neurological symptom of bipolar disorder is enlarged fluid-filled ventricles, meaning a decrease of brain matter (Fung et. al 2015). Subjects exhibiting high levels of divergent thinking (creative subjects) were found to have increased cortical thickness in left-brain areas (Haier et. al 2008).

As for white matter, as mentioned earlier, people with schizophrenia have out-of-sync neuronal firing in their frontal lobes. This is not associated with consistent myelin, and therefore suggests decreased white matter (Wible 2013). Subjects with bipolar disorder were found to have white matter abnormalities in the form of white matter lesions, meaning regions of white matter were damaged in some way (Fung et. al 2015). This would create interrupted neuronal communication, since neurons would not have an adequate amount of myelin to properly communicate . On the other hand, creative subjects had a greater amount of white matter than control subjects. This is because myelin is required for more rapid neural connections, which is a major component in overall divergent thinking (Takeuchi et. al 2011).

The actual brain structures involved in creativity vs. bipolar disorder/ schizophrenia will now be explored. In schizophrenia, the limbic system is the major brain region affected. This is primarily dysfunction in the hippocampus and amygdala. There were mixed results of decreased function and over-action in the frontal lobe, with the over-action occurring in the dorsal prefrontal cortex (Whalley et. al 2012) (Wible

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2013). Subjects with bipolar disorder had over-action in the limbic/meso-limbic regions, including the amygdala, hippocampus, parahippocampal gyrus, and mid-cingulate cortex (Whalley et. al 2012). Over-activation in the precentral gyrus and lateral parietal cortex was also discovered in bipolar disorder patients (Whalley et. al 2012). For creative subjects, the frontal lobes are crucial because of their role in working memory, semantic retrieval, episodic encoding and retrieval, priming, and explicit categorization (Haier et. al 2008). There was an increase in right parieto-temporal areas as compared to control subjects. There was also greater complexity over central and parietal cortices during tasks of divergent thinking in people exhibiting high creativity (Andreasen 1995). In such tasks, centroparietal cortices were associated with more original responses.

Conclusions and Future Study

In regards to a correlation between white matter and gray matter density, there is no correlation found between the brain matter in creative subjects in comparison to the brain matter found in subjects with bipolar disorder or schizophrenia. Creative subjects have an increase in grey and white matter while subjects with bipolar disorder or schizophrenia have a decrease. Some of the structural abnormalities do in fact overlap. Creative subjects are not especially stimulated in the limbic system as subjects with bipolar disorder and schizophrenia are. However, creative subjects rely on the frontal lobes, the same region where subjects with bipolar disorder and schizophrenia both showed over-action for an emotional prosody and associate memory task, respectively. An additional area of overlap is the parietal cortices, which were more activated (as

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compared to control subjects) for both creative subjects and subjects with bipolar disorder.

It is difficult to draw from these results whether or not neuroscience has an impact on creativity based on creativity's connection to mental illness. It is possible that this is because mental illness and creativity simply do not connect, which does not rule out the possibility of creativity being rooted in neuroscience. There was overlap in the frontal and parietal lobes, both of which are crucial for judgment, general awareness, and making connections (most association cortices are located in the parietal lobes). In future studies, those who have access to functional imaging equipment should continue to do scans for creative subjects as they complete divergent tasks. However, it would be interesting to do a functional imaging with creative subjects, and subjects suffering from bipolar disorder or schizophrenia, with the intention of finding possible neural connections. If areas were studied with researchers intentionally checking for correlations, it would be fascinating to see what (if anything) changed.

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AP® RESEARCH
2016 SCORING COMMENTARY

Academic Paper

Sample: H
Content Area: Understand and Analyze Context — Row 1 Score: 6
Content Area: Understand and Analyze Argument — Row 2 Score: 6
Content Area: Evaluate Sources and Evidence — Row 3 Score: 6
Content Area: Research Design — Row 4 Score: 5
Content Area: Establish Argument — Row 5 Score: 5
Content Area: Select and Use Evidence — Row 6 Score: 4
Content Area: Engage Audience — Row 7 Score: 2
Content Area: Apply Conventions — Row 8 Score: 6
Content Area: Apply Conventions — Row 9 Score: 2

MEDIUM SAMPLE RESPONSE

"The Neuroscience of Creativity as Shown Through the Neural Abnormalities of Bipolar Disorder and Schizophrenia"

Content Area: Understand and Analyze Context — Row 1
The response earned 6 points on this row because the first paragraph (Introduction) offers definitions of creativity and describes the paper's focus on the neurological indicators of creativity, specifically as they might correlate with bipolar disorder. The paper then shows why further investigation is necessary by indicating that various theories (e.g., regarding gray matter density, regarding verbal ability) need integration: "It is evident that the neuroscience of creative individuals has been explored, the connection of mental illness and creativity has been examined, and neural structures of those suffering from mental illness have been studied. However, by compiling data and details from the above studies and related experiments, one can gain a fuller understanding of how mental illness, creativity, and neuroscience interweave and affect each other (or not)" (p. 7).

Content Area: Understand and Analyze Argument — Row 2
The response earned 6 points on this row because the Literature Review includes multiple perspectives on whether creativity can be measured through neuroscience (and, if so, through which indicators), and whether there is a correlation between creativity and mental illness (specifically, bipolar disorder and schizophrenia). The various studies then form the basis for the student's own inquiry, which involves compiling and "interweaving" the different ideas.

Content Area: Evaluate Sources and Evidence — Row 3
The response earned 6 points on this row because most sources in the Literature Review are recent articles in peer-reviewed, social-science journals (see Bibliography). The various studies form the basis for the student's own inquiry, aimed at integrating the different findings (see top of p. 7).

Content Area: Research Design — Row 4
The response earned 5 points on this row because there is a statement about methods ("Correlational research and content analysis will be the major methods employed in this paper," p. 8), and a description of the kinds of correlations the content analysis might discover (pp. 8–9). The paper does not meet the standard for 7 points in this row because it does not provide a rationale for the choice of method other than "because of limited time and resources" (p. 8).

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2016 SCORING COMMENTARY

Academic Paper

Content Area: Establish Argument — Row 5
The response earned 5 points on this row because the evidence from the student's content analysis is clearly linked to the claims in the Results and Discussion sections. The paper did not earn 7 points on this row because consequences of the new understanding are not stated. For example, the Conclusions & Future Study section states two main conclusions: "There is no correlation found between the brain matter in creative subjects in comparison to the brain matter found in subjects with bipolar disorder or schizophrenia. Creative subjects have an increase in grey and white matter while subjects with bipolar disorder or schizophrenia have a decrease" (p. 18). There is no discussion of the implications of the conclusions.

Content Area: Select and Use Evidence — Row 6
The response earned 4 points on this row because several pages of evidence from the research studies included in the content analysis (pp. 10–16) appear to support the paper's two main conclusions (p. 18). The paper did not earn 6 points on this row because the profusion of evidence from several different studies is not interpreted or synthesized. See the paragraphs in Results (pp. 10–15) to note that studies' findings are summarized without analysis.

Content Area: Engage Audience — Row 7
The response earned 2 points on this row because it is adequately organized, in that each section is labeled and logically follows one another. The Analysis section does not provide analysis, though; it introduces additional results. The response did not earn 3 points because additional organizational or design elements would have enhanced the communication of the conclusions being made. For example, graphs or tables would have been helpful to organize the six pages of results in a more understandable way, and readers could have used a glossary or in-text definitions of technical terms (e.g., prefrontal cortex).

Content Area: Apply Conventions — Row 8
The response earned 6 points on this row because attributions are made clear and citations are correct throughout the paper. There is no doubt about what is the work of other scholars and what is the student's own voice.

Content Area: Apply Conventions — Row 9
The response earned 2 points on this row because it is well written overall with a few minor errors. It did not earn 3 points on this row because it lacks variety in syntax (e.g., several paragraphs begin with the phrase "Another study...").

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